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UPDATE TO THE ASSESSMENT FRAMEWORK FOR GOOSE BARNACLES (CAʔINWA[1]; *POLLICIPES POLYMERUS*) INCORPORATING LOCAL ECOLOGICAL KNOWLEDGE AND ADVANCEMENTS IN TECHNOLOGY IN CLAYOQUOT SOUND OFF THE WEST COAST OF CANADA

Goose Barnacles (Caʔinwa, Pollicipes polymerus)(Photo credit: T'aaq-wiihak Fisheries).

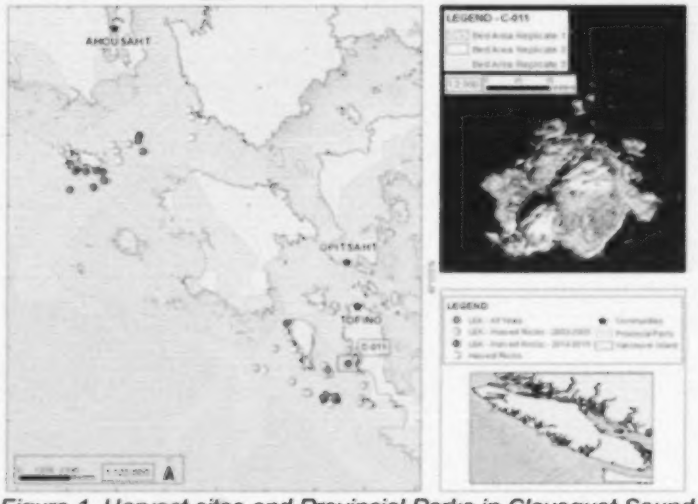

Figure 1. Harvest sites and Provincial Parks in Clayoquot Sound.

Context:

This Goose Barnacle Framework updates a general Framework for Goose Barnacles (Caʔinwa[1]; Pollicipes polymerus) in waters off the West Coast of Canada developed by Lauzier in 1999. The update incorporates a revised survey methodology and analytical procedures for estimating Goose Barnacle bed area and biomass with the inclusion of Local Ecological Knowledge (LEK). New analytical procedures using bootstrapping methodology for quantitatively estimating Goose Barnacle biomass and an LEK method for estimating biomass is evaluated and proposed. This Framework explores the concept of using harvest area closures as an alternative to a biologically-based provisional Limit Reference Point (LRP) and an Upper Stock Reference (USR).

This review was held in response to a request from Fisheries and Oceans Canada (DFO) Resource Management and First Nations to update an assessment protocol for the commercial harvest of Goose Barnacles, specifically within Clayoquot Sound, on the West Coast of Vancouver Island in British Columbia.

This Science Advisory Report is from the June 14 - 15, 2016 regional peer review on the Update to the assessment framework for Goose Barnacles (Pollicipes polymerus). Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

[1] Caʔinwa is the Nuu-chah-nulth word for Goose Barnacles.

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SUMMARY

- Five Nuu-chah-nulth-aht Nations (Ahousaht, Ehattesaht, Hesquiaht, Mowachaht/Muchalaht, and Tla-o-qui-aht) have led, in collaboration with Fisheries and Oceans Canada (DFO), the development of an updated assessment framework for Goose Barnacles. The updated assessment framework incorporates Local Ecological Knowledge (LEK) along with revised survey methodology and analytical procedures for estimating Goose Barnacle bed area using current GPS technologies and new analytical procedures to quantitatively estimate biomass.
- LEK is used to estimate the *harvestable* biomass which takes into consideration size range for market, accessibility and the ability to harvest live animals. LEK harvestable biomass is compared to quantitative estimates of total biomass and is found to represent an average of 4.6% (range 0.8 – 15.1%) of the quantitatively estimated total biomass.
- Goose Barnacle biomass estimates by rock are presented as probability distributions and reported in a decision table to allow managers to choose appropriate risk levels. The presented probabilities are $P_{10, 20, 30, 50, 70\%}$ which represent the probabilities that the true biomass is smaller than the estimate.
- A novel approach was used in the development of reference points compliant with the Precautionary Approach (DFO, 2009a):
    - The use of estimated total potential habitat as a proxy for virgin biomass (B_0) is recommended as an interim measure. This approach proposes provisional Limit Reference Points (LRP) and Upper Reference Points (URP) of 20% and 40% of estimated total potential habitat.
    - This approach is deemed appropriate in the unique case of Goose Barnacle in the Clayoquot Sound area due to the sessile nature of the organism, the data limitations associated with estimating population parameters, the small spatial scale on which it is being applied, and in recognition that the refugia are spatially integrated into the current harvest area meaning that larval connectivity is likely.
- The updated framework is proposed to be used specifically in Clayoquot Sound. However, it is adaptable for application in other areas along the coast of British Columbia.

INTRODUCTION

A general assessment framework for Goose Barnacles (*Ca?inwa*, *Pollicipes polymerus*) in waters off the West Coast of Canada was prepared and presented to the Pacific Scientific Advice Review Committee (PSARC) in 1999 (Lauzier, 1999a). Since the original framework was developed in 1999, advances in technology have provided an opportunity to update the survey methodology for estimating Goose Barnacle bed area and biomass on a rock-by-rock basis. New policies implemented by Fisheries and Oceans Canada (DFO), such as the Sustainable Fisheries Framework (DFO, 2009a) and specifically the Fishery Decision-Making Framework Incorporating the Precautionary Approach (DFO, 2009b), require additions to the original framework.

The existing Goose Barnacle Framework was revisited in response to a renewed interest in the Goose Barnacle fishery off the west coast of Vancouver Island (WCVI) from five First Nation communities. In *Ahousaht Indian Band et al. v. Canada and British Columbia (2009)*, the courts found that five Nuu-chah-nulth First Nations located on the WCVI (Ahousaht, Ehattesaht, Hesquiaht, Mowachaht/Muchalaht, and Tla-o-qui-aht) have "aboriginal rights to fish for any species of fish within their Fishing Territories and to sell that fish, with the exception of geoduck"

(DFO, 2016). Collectively the five plaintiff Nations took on the name of the *T'aaq-wiihak* Nations". T'aaq-wiihak means fishing with permission of the Ha'wiih (hereditary Chiefs).

The five First Nations have taken the lead, in collaboration with DFO, to develop an updated assessment that incorporates new technology and LEK into the science and management of the fishery. The updated framework was tested in Clayoquot Sound, located within three of the five First Nations' fishing territories. The proposed framework could potentially be adapted for application in other areas along the coast of British Columbia.

ANALYSIS

The proposed assessment framework updates include a new method for estimating bed area, methods for estimating biomass using both quantitative and LEK methods, and potential metrics for incorporation of the Precautionary Approach.

The first step for the quantitative population assessments is to delineate bed area (using a new method explained below) and then to apply a density estimate to the area to calculate (using a new method explained below) a Goose Barnacle biomass estimate by rock including a measure of uncertainty. A harvest rate (HR) is then applied to the biomass estimate to establish a maximum annual harvest level.

The LEK component is proposed for use as a method for estimating Goose Barnacle biomass when it is not feasible to conduct a quantitative assessment prior to harvest.

No new information or data were available to update the previously published information in Lauzier (1999 a,b) on growth, age, natural mortality (M), and corresponding appropriate harvest rate (HR).

The updated assessment framework was piloted on six rocks in Clayoquot Sound on the west coast of Vancouver Island that were surveyed and harvested in previous Goose Barnacle fisheries in the 1990's and 2003 to 2005.

GPS Bed Area Mapping Methodology

Trained technicians mapped the perimeter of each Goose Barnacle bed on a rock-by-rock basis using a GPS device. Ideally each bed was surveyed a minimum of three times by different surveyors to obtain a measure of variability, but this was not always possible. Then a geospatial mapping software was used to map bed area polygons, compare replicates, and determine bed area.

Biomass Estimation - Quadrat Method

The Goose Barnacle density data collected from all 395 quadrats were sampled from 19 rocks between 2000 and 2003 and used in the harvest rock biomass estimation for the six rocks in this framework.

A bootstrapping (Efron, 1981) procedure with Goose Barnacle densities was used to estimate total biomass for rocks with GPS mapped bed areas.

Biomass Estimation- Local Ecological Knowledge Method

Goose Barnacle LEK surveys were first implemented in 2003 to inform a variety of knowledge gaps related to the stock and fishery. Survey design involved conducting on-the-rock in-person interviews with experienced harvesters and knowledge holders with a history of harvesting in each area. To reduce variability in responses associated with tidal height and weather

conditions, all surveys were conducted during five foot low tides or less and only during daylight hours under suitable weather conditions.

To estimate Goose Barnacle biomass using LEK, an estimate of the *harvestable* Goose Barnacle product by rock was determined by calculating an average based on all LEK responders. The mean LEK estimations of *harvestable* biomass by rock were then compared to the quadrat estimated total biomass and a proportional relationship between LEK and quadrat biomass estimates was developed and presented.

Relationship between Local Ecological Knowledge and Quantitative Estimates

The following equation describes the relationship between the LEK estimate of harvestable biomass and the quantitatively estimated median total biomass ($P_{50\%}$) (QETB), and is used to calculate the estimated total biomass on a rock (ERB):

$$ERB_X = LEKHB_X * LEK\ ratio$$

Where:

$ERB_X = Estimated\ goose\ barnacle\ Biomass\ for\ Rock\ X$

$LEKHB_X = average\ LEK\ estimate\ of\ Harvestable\ Biomass\ for\ rock\ X$

$LEK\ ratio = {}^{1}/_{mean\ (LEKHB:QETB)\ over\ all\ rocks}$

Precautionary Approach

The development of a harvest strategy compliant with the Precautionary Approach (PA) is required for Goose Barnacles. The suggested default provisional reference points of 40% (LRP) and 80% (USR) of B_{msy} (the biomass that would provide the highest long-term average catch or maximum sustainable yield, MSY, of a fish stock) recommended within the PA policy are not feasible due to the lack of biological and time series data for Goose Barnacle stocks.

Reference points may also be expressed in terms of virgin biomass, B_0, with the LRP and USR expressed as 20% and 40% of B_0, respectively. The updated framework uses total potential habitat area as a proxy for B_0. Total potential habitat area is taken from the Intertidal-MUS bioband data (bioband for California mussel (*Mytilus californianus*) and Gooseneck Barnacle assemblage in mid-intertidal) of Howes et al. (2001). A total of 1,058,870.04 m^2 of potential Goose Barnacle habitat (potential bed areas) exists within Clayoquot Sound. The result would be a LRP of 211,774 m^2 and an USR of 423,548 m^2. To operationalize these reference points, the Goose Barnacle stocks within Clayoquot Sound would be considered in the healthy zone if a minimum of 423,548 m^2 of estimated potential Goose Barnacle habitat area remained as refugia.

Sources of Uncertainty

In this updated Goose Barnacle framework the sources of uncertainty that were not quantitatively incorporated include:

- Delineation of the bed during GPS surveys is somewhat subjective and influenced by surveyor behavior and environmental conditions.
- Total potential Goose Barnacle habitat area was taken from the Intertidal-MUS bioband of Howes et al. (2001), however the bioband data have not been groundtruthed and the proportion of occupied versus unoccupied total potential habitat area is unknown.

- There is inherent subjectivity in the LEK estimates by experienced harvesters.
- Density data estimates are from surveys conducted in 2003-2005 and from a combination of Barkley, Clayoquot and Kyuquot Sounds.

CONCLUSIONS AND ADVICE

The review of the updated assessment framework determined that the framework is suitable for use in Clayoquot Sound, and represents an improvement over the previous framework for the following reasons: bed area can now be mapped and estimated using advances in Global Positioning System (GPS) technology, new analytical procedures using bootstrapping allows biomass estimates to be presented as probability distributions, provisional reference points compliant with the PA are presented and quantifiable information acquired through LEK is included which adds considerable value and efficiency.

The following recommendations were made:

- Implement the updated assessment framework in Clayoquot Sound and potentially adapt and apply it to other areas along the coast of British Columbia.
- Adopt the LEK method for estimating total Goose Barnacle biomass for rocks with no bed area estimates.
- Adopt the refugia approach for provisional reference points as an interim measure. As additional information becomes available, it may be necessary to re-evaluate and update the provisional reference points to ensure compliance with the Precautionary Approach.
- Research and monitoring is recommended to:
    - continue to conduct bed area estimation and quantitative biomass estimates for rocks harvested solely based on LEK estimates.
    - collect data to update the relationship between LEK and quantitative biomass estimates.
    - study Goose Barnacle harvest recovery response.
    - groundtruth the Howes et al (2001) bio-band data and determine the proportion of occupied versus unoccupied potential habitat area.

SOURCES OF INFORMATION

This Science Advisory Report is from the June 14 - 15, 2016 regional peer review on the Update to the assessment framework for Goose Barnacles (*Pollicipes polymerus*). Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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